

U.S. Patent Application Serial No. 10/542,029
Amendment filed January 16, 2007
Reply to OA dated September 18, 2006

REMARKS

Claims 1-13 are pending in this application. The present amendment cancels claims 2-5 and 7 without prejudice or disclaimer, and amends claims 1 and 6. Upon entry of this amendment, claims 1, 6 and 8-13 will be pending. The Applicant respectfully submits that no new matter has been added. It is believed that this Amendment is fully responsive to the Office Action dated **September 18, 2006**.

Support for the amendment to claim 1 may be found in claims 2 to 5 and 7, which have accordingly been canceled without prejudice or disclaimer. Specifically, the limitation that “the purified aliphatic sulfonic acid is one obtained by purifying an aliphatic sulfonic acid which has been produced by hydrolyzing an alkylsulfonyl halide” is supported by original claim 7. The limitation that “the content of dimethyldisulfide in the plating bath is less than 200 ppm” is supported by original claim 2. The limitation that “the content of S-methyl methanethiosulfonate in the plating bath is less than 4 ppm” is supported by original claim 3. The limitation that “the content of α -chlorodimethylsulfone in the plating bath is less than 4 ppm” is supported by original claim 4. The limitation that “the content of α -methylsulfonyl- α,α -dichlorodimethylsulfone in the plating bath is less than 4 ppm” is supported by original claim 5.

Claim 1 is objected to. (Office action page 2)

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The Examiner states that on line 11, --wherein-- should be inserted before "the," and that "being" be changed to "is." The amendment to claim 1 incorporates the suggested grammatical changes.

Claims 1-13 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the applicant regards as the invention. (Office action page 2)

The rejections of claims 2-5 and 7 are moot in view of the cancellation of these claims without prejudice or disclaimer. The rejections of claims 1, 6, and 8-13 are overcome by the amendments to claims 1 and 6. Specifically, the recitation of "in the molecule" has been eliminated in the claims, and the amendment clarifies that "an aliphatic sulfonic acid" is purified to become "the purified aliphatic sulfonic acid."

Claims 1-12 are rejected under 35 U.S.C. 103(a) as being unpatentable over WO 00/31027 ('027) and Eiermann et al. (U.S. Patent No. 6,531,629 B1) in combination with Nobel et al. (U.S. Patent No. 4,871,429). (Rejection I, Office action page 4)

The rejection is moot for claims 2-5 and 7, which have been canceled without prejudice or disclaimer. Reconsideration of the rejection of pending claims 1, 6 and 8-13 is respectfully requested in view of the amendments to the claims.

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The Examiner cites Eiermann for disclosing a tin-containing plating bath (citing column 1, lines 6-13) comprising an aliphatic sulfonic acid meeting the impurity limitations of claim 1, citing column 6, lines 32-36 and 41-44, and column 5, lines 20-38. The Examiner then states that Eiermann does not disclose the soluble stannous salt recited in claim 1, but cites Nobel for disclosing a bath containing stannous salts.

Eiermann et al. (US Patent No. 6,531,629) relates to a process for the preparation of alkanesulfonic acids, and discloses that the obtained alkanesulfonic acids can be used as auxiliary chemicals for the electrodeposition of noble metals such as tin or lead in the tin plating of printed circuit boards for electronics. Eiermann et al. discloses, as a process for the preparation of alkanesulfonic acids, the oxidation of alkylmercaptans and/or dialkyl disulfides and/or dialkyl polysulfides with nitric acid to form alkanesulfonic acids, and also discloses that methanesulfonic acids obtained after purification (vacuum distillation) are suitable for use in electrochemical baths.

By contrast, in amended claim 1, a purified aliphatic sulfonic acid obtained by purifying an **aliphatic sulfonic acid which has been produced by hydrolyzing an alkylsulfonyl halide** is used as the acid in the tin-containing plating bath of the present invention. Due to the impurities resulting from the different preparation methods, an alkanesulfonic acid produced by the method of the reference will not have the same composition as an aliphatic sulfonic acid produced by the method recited in claim 1. Moreover, claim 6 requires the presence of "at least two sulfur-containing compounds selected from the group consisting of dimethyldisulfide, S-methyl methanethiosulfonate,

α -chlorodimethylsulfone and α -methylsulfonyl- α,α -dichlorodimethylsulfone” in the plating bath, which would not be the case with the bath in Eiermann et al.

As disclosed on page 7, lines 21 to 23, of the present specification, an aliphatic sulfonic acid obtained by hydrolyzing an alkylsulfonyl halide may contain various halogen- and sulfur-containing compounds as impurities. In amended claim 1, the content of these sulfur-containing compounds in the tin-containing plating bath is limited as follows: less than 200 ppm of dimethyl disulfide, less than 4 ppm of S-methyl methanethiosulfonate, less than 4 ppm of α -chlorodimethylsulfone, and less than 4 ppm of α -methylsulfonyl- α,α -dichlorodimethylsulfone.

Eiermann et al. discloses a purification step performed by vacuum distillation of alkanesulfonic acids produced by oxidizing alkylmercaptans and/or dialkyl disulfides and/or dialkyl polysulfides with nitric acid. The alkanesulfonic acids produced by the oxidation disclosed in Eiermann et al. originally have no halogen- and sulfur-containing compounds as impurities.

Therefore, the aliphatic sulfonic acids used in the present invention are clearly different from the alkanesulfonic acids produced by the oxidation disclosed in Eiermann et al. Applicant submits that Eiermann et al. does not inherently disclose a bath meeting these limitations on the impurities.

In addition, Applicant submits that the limitations on impurities recited in claim 1 provides an **unexpected** effect on the performance of the plating bath.

The present inventors have studied the influence of impurities, which are contained in aliphatic sulfonic acids used as a base acid in the tin-containing plating bath, on plating properties. As a result, the inventors found that only specific sulfur-containing compounds among the various

sulfur-containing compounds contained in aliphatic sulfonic acids adversely affect plating properties, and other sulfur-containing compounds have no influence on plating properties.

More specifically, the present inventors found that dimethyl disulfide, S-methylmethanethiosulfonate, α -chlorodimethylsulfone, and α -methylsulfonyl- α , α -dichlorodimethylsulfone disclosed on page 8, line 33, to page 9, line 15, of the present specification have influence on the properties, in particular on the reflowability and appearance, of tin plating films or tin alloy plating films. In addition, plating films having excellent properties can be obtained by using the aliphatic sulfonic acid which is purified so that the content of each sulfur-containing compound in the plating bath is as follows: less than 200 ppm of dimethyl disulfide, less than 4 ppm of S-methyl methanethiosulfonate, less than 4 ppm of α -chlorodimethylsulfone, and less than 4 ppm of α -methylsulfonyl- α , α -dichlorodimethylsulfone.

Eiermann et al. is totally silent about the influence of specific impurities, which are contained in the alkanesulfonic acids, on the properties of tin-containing plating films. Therefore, the improvement in reflowability and appearance of plating films to a substantial degree by using the aliphatic sulfonic acid which is purified so that the content of each sulfur-containing compound in the plating bath is as follows: less than 200 ppm of dimethyl disulfide, less than 4 ppm of S-methyl methanethiosulfonate, less than 4 ppm of α -chlorodimethylsulfone, and less than 4 ppm of α -methylsulfonyl- α , α -dichlorodimethylsulfone is completely **unexpected** over Eiermann et al.

Nobel et al. (US Patent No. 4,871,429) discloses the use of soluble metal salts in a tin plating bath or tin alloy plating bath. There is no disclosure or suggestion in Nobel et al. for use of an

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aliphatic sulfonic acid produced by hydrolyzing an alkylsulfonyl halide as a base acid in a tin-containing plating bath. In addition, there is no suggestion in Nobel et al. for the effects resulting from the limitations of claim 1, and these results are completely **unexpected** over Nobel et al.

Claims 6 and 8 to 12 of the present application are all dependent on claim 1 and relate to a tin-containing plating bath comprising, as a base acid, a purified aliphatic sulfonic acid obtained by purifying an aliphatic sulfonic acid which has been produced by hydrolyzing an alkylsulfonyl halide. Accordingly, the plating baths of claims 6 and 8 to 12 are unobvious over Eiermann et al. and Nobel et al. for the same reason as that which applies to claim 1.

Therefore, claims 1, 6, and 8-12 are not obvious over Eiermann et al. and Nobel et al., taken separately or in combination.

Claim 13 is rejected under 35 U.S.C. 103(a) as being unpatentable over WO 00/31027 ('027) and Eiermann et al. (U.S. Patent No. 6,531,629 B1) in combination with Nobel et al. (U.S. Patent No. 4,871,429) as applied to claims 1-12 above, and further in view of IBM (Technical Disclosure Bulletin, Vol. 32, No. 3B, August 1, 1989, pp. 36-37). (Rejection II, Office action page 9)

Reconsideration of the rejection of claim 13 is respectfully requested in view of the amendments to the claims.

IBM Technical Disclosure Bulletin is cited for electroplating tin/lead eutectic solder to form a solder bump.

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Applicant notes that IBM Technical Disclosure Bulletin discloses using electrolytic tin/lead eutectic solder plating for the formation of a solder bump. However, IBM Technical Disclosure Bulletin does not disclose or suggest a tin-containing plating bath satisfying the limitations of claim 1, from which claim 13 depends. Applicant further submits that the results of the present invention, discussed above as being unexpected over Eiermann et al. and Nobel et al., would also be unexpected over IBM Technical Disclosure Bulletin.

Therefore, the invention of claim 13 having a feature of using the plating bath specified in claim 1 is not obvious over Eiermann et al., Nobel et al. and IBM Technical Disclosure Bulletin, taken separately or in combination.

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If, for any reason, it is felt that this application is not now in condition for allowance, the Examiner is requested to contact the Applicant's undersigned agent at the telephone number indicated below to arrange for an interview to expedite the disposition of this case.

In the event that this paper is not timely filed, the Applicants respectfully petitions for an appropriate extension of time. Please charge any fees for such an extension of time and any other fees which may be due with respect to this paper, to Deposit Account No. 01-2340.

Respectfully submitted,

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